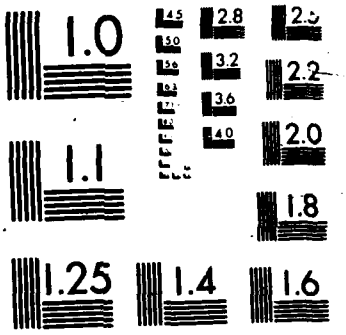
AD-A172 896 DEVELOPMENT OF CONSTITUTIVE EQUATIONS IN NONLINEAR AEROSPACE MATERIALS AN..(U) TEXAS A AND M UNIV COLLEGE STATION DEPT OF AEROSPACE ENGINEER.. D H ALLEN APR 85 1/1

UNCLASSIFIED AFOSR-TR-86-0857 AFOSR-84-0257 F/G 20/11 NL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Mechanics and Materials Center
TEXAS A&M UNIVERSITY
College Station, Texas

Final Contract Report

for

DOD-University Research Instrumentation Program

Development of Constitutive Equations in Nonlinear Aerospace Materials and Structures

by

David H. Allen
Assistant Professor
Aerospace Engineering Department
Texas A&M University
College Station, Texas 77843

to the

Air Force of Scientific Research
Office of Aerospace Research
United States Air Force
Contract No. AFOSR-84-0257

April 1985

SECURITY CLASSIFICATION OF THIS PAGE

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12. PERSONAL AUTHOR(S): D.H. Allen	
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16. SUPPLEMENTARY NOTATION	

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	experimental methods, composite, elevated temperature, plasticity, damage, viscoelasticity

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The instrumentation purchased under this contract is a Materials Testing System (MTS) Model 880 uniaxial testing machine. The equipment is described in detail in the original DOD Equipment Grant Proposal. In general, the system is used to perform mechanical tests on aerospace structural materials under prescribed thermal conditions. Typical aerospace materials being tested include polymeric composites, metal-matrix composites, and nickel-based metals. These materials are utilized both in space structures and advanced military aircraft. The primary objective of the equipment is to provide experimental data necessary to characterize the thermomechanical material properties of the structural materials mentioned above.

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Contract No. AFOSR-34-0257

April 1985

ABSTRACT

The instrumentation purchased under this contract is a Materials Testing System (MTS) Model 880 uniaxial testing machine. The equipment is described in detail in the original DOD Equipment Grant Proposal. In general, the system is used to perform mechanical tests on aerospace structural materials under prescribed thermal conditions. Typical aerospace materials being tested include polymeric composites, metal-matarix composites, and nickel-based metals. These materials are utilized both in space structures and advanced military aircraft. The primary objective of the equipment is to provide experimental data necessary to characterize the thermomechanical material properties of the structural materials mentioned above

PROCUREMENT SCHEDULE

The following is a calender of the equipment procurement schedule:

Final Bid Date: June 11, 1984
Contractual Agreement Date: July 1, 1984
Equipment Receipt Date: March 1, 1985
Equipment Acceptance Date: March 21, 1985
Fund Release Date: March 21, 1985

EQUIPMENT RECEIVED

The equipment received is detailed in the attached quotation no. 63311-4. There were two minor modifications made in the equipment as received:

1) Item V.B. changed from 6332.41B-04 to 632.41B-02 axial quartz extensometer and;
2) Item V.G. changed from 1,000 lb. load cell to 10,000 lb. load cell.

The acquisition of these items increased the overall system price by $450 to $187,105. The increased cost was 100% cost-shared by Texas A&M. These minor changes were incorporated to better achieve the research goals.

RESEARCH SUPPORTED BY THE EQUPMENT

The equipment will be utilized primarily in support of the following research:

a) AFOSR contract no. F49620-83-C-0067 entitled "A Model For Predicting Thermomechanical Response of Large Space Structure," with principal investigators D.H. Allen and W.E. Haisler.

The objective of this research is to develop, using experimental and analytic methods, constitutive equations for metal matrix and polymeric composites as well as high strength metal alloys which are capable of modeling response due to environmental and thermomechanical effects in space. Further, these models are to be implemented to structural analysis models appropriate for space structures, and the resulting models are to be utilized to assess the effects of material inelasticity and degradation on the response of space structures.

b) AFOSR grant no. AFOSR-84-0067 entitled "Damage Models for Continuous Fiber Composites," with co-principal investigators D.H. Allen and C.E. Harris.

The objective of this research is to develop a precise damage model for predicting strength and stiffness of continuous fiber composite media subjected to fatigue loading and to verify this model with experimental results.

In addition, the equipment will be utilized to a lesser extent on the following research projects:

a) AFOSR grant no. AFOSR-84-0069 entitled "Delamination and Transverse Fracture in Graphic/Epoxy Composites," principal investigator W.L. Bradley.

b) AFOSR grant no. AFOSR-84-0069 entitled "Residual-Stress Induced Damage in Composite Materials," principal investigator Y. Weitsman.

c) AFOSR grant no. AFOSR-84-0068 entitled "Damage Models for Delamination and Transverse Fracture in Fibrous Composites," principal investigator R.A. Schapery.

d) AFOSR grant no. AFOSR-84-0066 entitled "Ultrasonic Nondestructive Evaluation of Damage in Continuous Fiber Composites," principal investigator V.K. Kinra.

e) NASA Lewis grant no. NAG3-491 entitled "Development of Constitutive Models for Cyclic Plasticity and Creep Behavior of Super Alloys at High Temperature," co-principal investigators W.E. Haisler and D.H. Allen.

MTS

QUOTATION NO. 63311-4

QUOTATION DATE June 11, 1984

VALID UNTIL August 1, 1984

CUSTOMER INQUIRY NO. Verbal

Texas A & M University
Dr. Dave Allen
Aerospace Engineering
Old Engineering Bldg. Room 215
College Station, Texas 77840

FOR FURTHER COMMUNICATION ON THIS QUOTATION CONTACT: Robert G. Sornsen
(214) 221-2713

Shipment Schedule
6 months A.R.O.

Shipment Terms
F.O.B. College Station

Terms of Payment
(The attached Conditions of Sale also form a part of this quotation.)
18% with placement of order
72% on delivery
10% on acceptance
Net 10 days

Equipment Packed For
Padded van

ITEM	DESCRIPTION	QTY	UNIT PRICE	TOTAL AMOUNT
	MTS MODEL 880 MATERIAL TEST SYSTEM including the following items: I. Load Unit II. Hydraulic Power Supply III.(A) Electronic Console III.(B) Computer Control IV. System Services V. Accessories NOTE: See the enclosed MTS 880 Catalog/Product Specifications for further product descriptions.			
NOTE:	*Please reference the above quotation number on any correspondence related to this quotation*			

Prepared by: Robert G. Sornsen

Address order to: MTS SYSTEMS CORPORATION
P. O. Box 587
Lewisville, Texas 75067

MTS
MTS SYSTEMS CORPORATION
BOX 24012 MINNEAPOLIS, MINNESOTA 55424
TELEPHONE 612 937-4000 TELEX 29-0521 MTS SYSTEM EMPE

QUOTATION CONTINUATION

Quotation No: 63311-4 Customer Name: Texas A & M University Sheet 2 of 6

ITEM	DESCRIPTION	QTY	UNIT PRICE	TOTAL AMOUNT
I.	LOAD UNIT - Model 380.50			
	A. Two column unit fatigue rated at 110,000 lbs., 11 feet maximum height.	1		
	B. Force transducer integrated into crosshead, fatigue rated at 110,000 lbs. calibration to four ranges included (100%, 50%, 20%, and 10% of maximum capacity).	1		
	C. Actuator, fatigue rated at 110,000 lbs. Full 6 in. stroke LVDT internally mounted and calibration to four ranges.	1		
	D. Hydraulic service manifold Model 294.12 equipped with remote controlled low pressure safety switch and slow turn on/slow turn off functions with a Model 252.25 Servovalve, 15 gpm and system hydraulic hoses, 25 ft. length	1		
	E. Local frame controls and hardware for actuator movement, hydraulic lifts, locks and grip control	1		
	F. Studs and spiral washers for grip interface	1		
II.	HYDRAULIC POWER SUPPLY - Model 506 10 gpm flow at 3000 psi. Required 460 VAC, 60 Hz, 3 phase power (and a cooling water supply). Interlocked for fluid high temperature or fluid low level conditions.	1		
III(A)	ELECTRONIC CONSOLE			
	A. Single bay console with usable equipment rack space of 52.5" x 19". Includes rear entrance doors, power panel, casters with leveling feet, dual blower unit with air filter and writing top drawer.	1		

QUOTATION CONTINUATION

Quotation No: 63311-4 Customer Name: Texas A & M University Sheet 3 of 6

ITEM	DESCRIPTION	QTY	UNIT PRICE	TOTAL AMOUNT
	B. Test controller Model 448.82 providing closed loop control of load, stroke, and strain. The following plug-in modules are included:	1		
	1. Servocontroller	1		
	2. Valve driver	1		
	3. DC transducer conditioner for load and strain readout and control	2		
	4. AC transducer conditioner for stroke readout and control	1		
	5. Feedback Selector	1		
	6. Limit detector	1		
	D. Master control unit Model 413.81 controls all electrical and hydraulic power to the system. An 8 digit counter is incorporated.	1		
	E. Digital data display Model 464.80 simultaneously monitors up to six channels of high level analog output signals, e.g., load, strain, and stroke. Data is displayed by channel number, channel name, and engineering units. Includes four operating modes; DC/DC, Max/Min, Span/Mean, and Peak/Valley. Each channel has an independent peak reading memory to permit recall of maximum values attained. Unit has two independent alphanumeric display. An optional printer is available for logging of data.	1		

QUOTATION CONTINUATION

Quotation No: 63311-4 Customer Name: Texas A & M University Sheet 4 of 6

ITEM	DESCRIPTION	QTY	UNIT PRICE	TOTAL AMOUNT
III.B	A. Computer Control hardware configuration including: 1. Test processor Model 468 with: a. Micro segment generator for computer controlled command generation. b. 8 channels of data acquisition, 14 bit resolution c. QDB d. Communications Link e. Programmable Clock on QDB 2. CPU, DEC Micro PDP11, 256K byte 3. Terminal DEC Model VT240 4. RX50 Dual 5¼" 400K bytes floppy disk & 10.2 m byte Winchester drive for mass storage B. Software configuration including: 1. MTS BASIC 2. Foundation modules for 880 application software 3. RT11 4. Diagnostics - systematically checks system for proper operation. 5. Software Development - includes string substitution/editing, renumbering/resequencing, cross-reference generation, PRINT... USING capability.			

QUOTATION CONTINUATION

Quotation No: 63311-4 Customer Name: Texas A & M University Sheet 5 of 6

ITEM	DESCRIPTION	QTY	UNIT PRICE	TOTAL AMOUNT
	6. Critical Event Processing - allows programs to branch, continue, or terminate as a result of real time test-generated interrupts.			
	7. Data Management - allows use of large regions of upper computer memory for storage of test data.			
	8. Conditioner Control - enables computer control of servo-controller ranges and zeros.			
	9. Graphics - provides software control of graphics display area; axes and grid markings; scaling, plotting and labelling of test data, with LA50 for hardcopy.			
	10. D/A Support			
IV.	SYSTEM SERVICES			
	A. Assembly and checkout at MTS' plant in Minneapolis prior to shipment.	1		
	B. Calibration at MTS' plant prior to shipment. (Customer to specify calibration units.)	1		
	C. System accessories and spares.	1		
	D. System Manuals -Operation -Maintenance -Reference	1 Set		
	E. Installation assistance and informal training at customer site by local MTS Field Service Engineer.	1		
	F. One (1) year warranty on all system components.			$138,690 Total Price Items I thru IV

QUOTATION CONTINUATION

Quotation No: 63311-4 Customer Name: Texas A & M University Sheet 6 of 6

ITEM	DESCRIPTION	QTY	UNIT PRICE	TOTAL AMOUNT
V.	OPTIONAL ACCESSORIES			
	A. Wedge Action Grips, Model 647.14A rated at ±55,000 lbs. with wedges for flat and round specimens, including a Model 641.91 Pressure Unit.	1		$ 15,225
	B. Extensometer, Model 632.41B-04, for 1000° C. operation	1		$ 5,605
	C. Model 652.01 High Temperature 1000° C. Clam Shell Furnace, including Hi Temperature Water Cooled Grips, pull rods, extensometer heat shield, and mounting bracket.	1		$ 11,225
	D. Model 651.12B-01 Environmental Chamber, -250° to +600° F. range, including LN^2 cooling, Model 409.80 Digital Temperature Controller and mounting brackets.	1		$ 10,105
	E. Model 632.11B-20B Extensometer	1		$ 1,125
	F. Model 661.12B-05, 100 lb. Load Cell	1		$ 1,300
	G. Model 661.16C-01, 1,000 lb. Load Cell	1		$ 1,980
	H. Additional 256K Bytes of memory	1		$ 265
	J. TG 34 Grips	1 Set		$ 700
	K. Floating Point Processer	1		$ 435
	The above prices are exclusive of federal, state or local taxes.			

END

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